



Get Ready, Get Set:
**Visibility at
the Grid Edge**

Utilities need new tools to retain a position as provider and enabler for energy consumers.

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Welcome

Ready or not, here they come. Electric utilities haven't been able to maintain distribution systems operations at the status quo level for many years. First it started with automation, then AMI, then smart grid. Now, as the calls for decarbonization and increased electrification grow louder, utilities must figure out how to integrate distributed energy resources, engage educated and demanding consumers, and manage loads from the increasing prevalence of electric vehicles.

To "figure all that out," utilities need to have full visibility and knowledge at the edge of the grid. "The distribution grid must become the Intelligent Grid – a living, breathing organism, capable of analyzing local conditions and responding in the right place at the right time, within centrally established guidelines," according to Tim Driscoll, director of Technology Strategy and Innovation at Itron, Inc.

This ebook begins to explain why distributed intelligence is relevant now and what's next after AMI installations. The first two stories describe how

distributed intelligence-enabled meters can increase that visibility and asset control. Tampa Electric Co. shares the results of its multi-phase pilot testing distributed intelligence vs. back-office analytics.

Next, T&D World Technology Editor Gene Wolf highlights how utilities need to get ready for the increase in electric vehicles on the road (and making demands of the grid).

After that, ComEd writes about its realization that it needed to calculate the values of DERs accurately so it could control the distribution grid. The utility developed its own methodology to gain that intelligence at the grid edge, helping to defer traditional grid investments.

As Gene Wolf put it in the story, Getting the Grid Ready, "Of course there are issues and challenges, but isn't that the way of today's new trending technologies?"

— Nikki Chandler, Associate Content Director, T&D World

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Making a Business Case for More Intelligence at the Grid Edge

Grid edge intelligence empowers business transformation, evolves distribution grid operations, enhances customer experience.

TIM DRISCOLL — ORIGINALLY PUBLISHED JUNE 24, 2021

The future of our modern grid is dependent on leveraging more distributed intelligence (DI) at the grid edge to help manage growth, stability, and safety. The move toward a smart grid also has a strong business case. Utilities that have implemented advanced metering infrastructure (AMI) investments are now nearing a breaking even point. But the good news is adding DI can create a positive business case without any consumer behavioral change, leading to nearly US\$50 million net business case benefit from DI for just a US\$22 million investment, and this number continues to grow.

Adding more intelligence means moving processes from the central office and distributing them throughout the grid. The added visibility from this DI ensures utilities and critical infrastructure operators will be able to meet the shifting requirements of their customers while improving safety and efficiency.

One utility currently at the forefront of testing and implementing DI applications is Tampa Electric Co. (TECO). TECO completed the first-ever field trial deployment of DI-enabled meters with Itron and is currently testing DI applications to improve overall operational efficiencies and improve customer relationships.

DIGITAL TRANSFORMATION AND DI

More intelligence at the edge provides additional visibility and control of assets to gain greater efficiencies. It also drives an entirely new customer experience by providing proactive ways to engage with customers, optimizing the effectiveness of load control, demand response, and dynamic pricing programs. DI minimizes the amount of data you must

transmit to the back office to analyze and make decisions, which is time-intensive, ineffective, and costly. Pushing the analysis to the edge helps resolve issues faster, saving both time and resources spent chasing symptoms, more proactively.

According to David Lukcic, TECO's director of AMI strategic solutions, TECO's shift toward embracing DI began as an extension of broader digital transformation initiatives around the automation of data and services. The journey to DI was natural and supported a transformational investment in new customer experience and operational programs. The energy company had already maximized the benefits of AMI investments and was looking toward the future in ways to improve overall service delivery and provide additional revenue opportunities to offset the continued costs of upgrading grid infrastructure.

The proposed benefits of DI offer significant value to utilities, including the ability to:

- » Manage rapidly changing conditions in real time.
- » Enable an increasingly diverse ecosystem of smart meters, grid devices, and distributed energy resources (DERs) that communicate and collaborate.
- » Establish measured improvements in grid efficiency, including location awareness, safety and reliability, and outage detection and restoration.
- » Transform customer service by optimizing the effectiveness of load control, demand response, and dynamic pricing programs.
- » Maintain distribution network stability and operation by monitoring and managing operations in real time.

DI helps improve safety, address energy use, and build stronger relationships with customers — adding more value to all parties. DI empowers an open and vibrant ecosystem of solution providers and applications for both utilities and customers. For example, DI allows energy companies like TECO to manage transactions and power flows in real time, all setting the stage for a future dynamic grid.

PUTTING EDGE ANALYTICS TO THE TEST

The promise of DI is shifting intelligence and analytical processing to the edge, replacing costly and inefficient traditional back-office data operations. TECO developed a multi-phase test that first pitted DI applications against traditional back-office analytics programs to validate DI's real value for itself and the industry as well, to be followed by field tests later this year.

The goal of the trial was to see if DI would result in a higher yield with less inference and wasted resources, like having to send crews to the field to chase things that may not be there. With faster decisions based on more valuable information, TECO was hoping to see a significant drop in the total cost of ownership with less data backhauled, stored, or analyzed in the back office.

The first phase of testing was against three DI use cases—meter-bypass theft, neutral-fault detection, and high-impedance detection. These tests ran over a month in a controlled lab, and the results were promising.

The DI apps and cloud analytics detected all meter-bypass theft use cases, but the big difference was DI triggered no false positives where the cloud analytics triggered seven. These false positives should be lower in field trials as algorithms are tuned by training machine learning algorithms with more data. DI proved itself in neutral-fault detection and high-impedance detection, being able to capture all use cases in each category accurately.

Only DI has the capability to observe broken neutral issues in a 2S meter configuration, the most common meter form in North America. The 2S meter only measures line-to-line voltage, and the required data frequency to discriminate and compute broken neutral conditions from available meter measurements is just not viable in a centralized cloud approach.

Capturing the signatures of high-impedance faults is not possible when the frequency of meter data is sent every 5 to 15 mins in a centralized, back-office cloud model. Having the ability to track, in advance, DI meters at 1 sec or sub-second increments allows for a wider variety of use cases that can be detected.

LOOKING AHEAD

TECO's lab results validate the benefits of DI applications by gaining actionable information and a new perspective on problem-solving from more granular real-time data. Shifting critical safety and customer impact issues a utility would treat on failure are now identified and proactively remediated to provide greater efficiencies and cost-savings while delivering a more exceptional customer experience. The utility is developing a white paper to share later this year and is currently preparing for field trials with plans to deploy apps to the meter farm and then production meters beginning this summer.

The bottom line is grid edge intelligence empowers business transformation, evolves distribution grid operations, and enhances customers' experience with proven, innovative applications that are managing the active grid of today and tomorrow.

Author: *Tim Driscoll is director of Technology Strategy and Innovation at Itron, Inc. Tim is a pioneer in the distributed intelligence field, demonstrating the utility industry's first meter based distributed intelligence applications in 2015, the utility industry's first field deployment of DI applications in 2018 and overseeing the utilization of the "app" model concept for deployment of distributed intelligence applications to utility meters in general. Tim is an author of multiple patents associated with distributed intelligence field. Tim has been in the utility industry for more than 30 years, 20 of which he spent at Itron. Prior to his time at Itron, Tim worked as a utility distribution engineer and as a utility load researcher and forecaster prior. Tim holds a bachelor's degree in mathematics and a bachelor's degree in electrical engineering, both from Dalhousie University in Canada, and he is a registered professional engineer.*

What is Driving Today's Distribution Grids to Become Tomorrow's Intelligent Grids?

This article will describe and analyze the three main drivers that are accelerating the use of distributed intelligence in electricity distribution network operations and consumer engagement, the principal use cases, and why utilities should take notice.

TIM DRISCOLL — ORIGINALLY PUBLISHED APRIL 7, 2020



Distributed intelligence—the distribution of analysis, decisions and action away from a central control point—is not a new concept. From smart phones running mobile apps, to supply chain management solutions, to multiplayer online gaming, distributed intelligence and computing has proven to be a consistently effective approach to managing large, complex, data-intensive systems and organizations. And the Internet of Things is only accelerating this trend.

So, why is this trend so relevant now for electric utilities? This article will describe and analyze the three main drivers that are accelerating the use of distributed intelligence in electricity distribution network

operations and consumer engagement, the principal use cases, and why utilities should take notice. The three drivers, in brief:

Grid Stability. The traditional utility model has been centralized on monitoring and control, but something big has changed. Since the dawn of electric utilities, load has been the key variable, and utilities have *controlled* generation and power flow to respond to changing load. In fact, control is the “C” is SCADA. With the emergence of distributed generation, all three of these are now variables—load, generation and power flow—not controlled by the utility. In this new world, the centralized control model simply

does not work because there's nothing to centrally control. Instead, the distribution grid must become the Intelligent Grid – a living, breathing organism, capable of analyzing local conditions and responding in the right place at the right time, within centrally established guidelines. This simple fact is one of the principal drivers behind distributed intelligence in the utility space, manifested in many distributed intelligence apps such as location awareness, active transformer load management, active voltage management and others.

Consumer Transformation. There are actually two drivers here for customer transformation. The first is that utility consumers expect more. They expect instant notification, proactive energy savings and environmental programs, and a continually evolving pallet of service offerings. They are not being unrealistic or unreasonable since they already experience that same level of service in most of their vendor relationships. Distributed intelligence applications such as local load disaggregation-based Energy Audit, Active Demand Response and Appliance Health Monitoring help fill this gap in expectation. Apps such as the Distributed Outage Identification and Location application enable more rapid, accurate customer communication when service is lost and more rapid power restoration.

The second consumer transformation driver is the impending competition from non-traditional players. As giant tech companies and communication network companies invest in the energy management space, it has become clear that their goal is to step between the utility and the customer and own the local transactions that will occur in the distributed grid. Their goal is to be the first point of contact to the customers with local-market-capable technologies. Utilities can address this competition with advanced distributed intelligence applications. For example, applications such as the Real-Time Markets, which ensures that utilities have the infrastructure and capabilities in place to manage real-time local transactions as those markets open and maintain their financial position in those transactions.

Operational Efficiency: There are many opportunities for grid operation efficiency that have existed since the dawn of utilities, but the costs of achievement have traditionally exceeded the benefits. In

many cases, these improvements, particularly in the low voltage network, could have theoretically been achieved with deployment of SCADA to every home. Unfortunately, the payback would have been measured in centuries, not years. Now, with the cost of distributed intelligence at the edge available for the same price as traditional “smart” meters, these efficiency use cases have become practical to implement. These are the more ordinary use cases, such as High Impedance Detection, Broken Neutral Detection, Theft Detection and Transformer Overload Identification, but they often drive utility distributed intelligence business cases as they provide savings against real OpEx expended today by every utility.

Edge processing has become a hot topic, and with distributed intelligence, utilities and cities can realize numerous benefits from the intelligent grid.

Author: *Tim Driscoll is director of Technology Strategy and Innovation at Itron, Inc. Tim is a pioneer in the distributed intelligence field, demonstrating the utility industry's first meter based distributed intelligence applications in 2015, the utility industry's first field deployment of DI applications in 2018 and overseeing the utilization of the “app” model concept for deployment of distributed intelligence applications to utility meters in general. Tim is an author of multiple patents associated with distributed intelligence field. Tim has been in the utility industry for more than 30 years, 20 of which he spent at Itron. Prior to his time at Itron, Tim worked as a utility distribution engineer and as a utility load researcher and forecaster prior. Tim holds a bachelor's degree in mathematics and a bachelor's degree in electrical engineering, both from Dalhousie University in Canada, and he is a registered professional engineer.*

... Seeing Both Kinds of Green: An Analysis of the Benefits

Recent analysis by Itron has given added detail to the cost benefits of optimized EV charging. "We took a school bus use case and dove into the details to quantify the benefit of managed charging for both the end customer and utility," says Mark Braby, head of eMobility, payments, data for Itron.

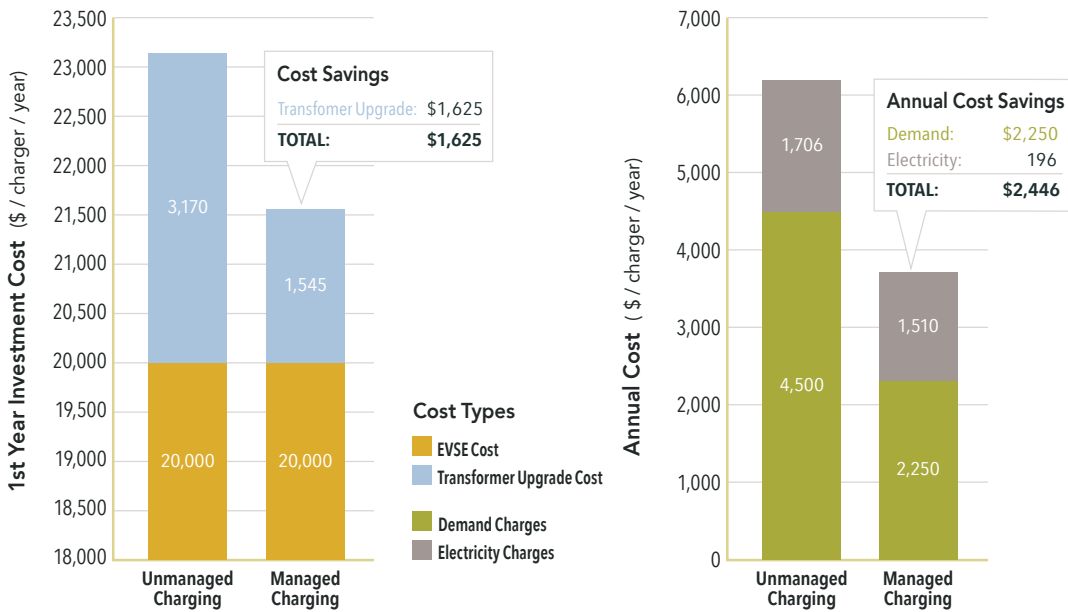


Figure 2. Managed EV charging saves the fleet owner over \$244,000 annually and minimizes up-front costs. Itron's projection shows that smaller equipment, less maintenance and off-peak pricing combine for an impressive 38% benefit over the lifespan of a 100-bus fleet and its 100 chargers.

Itron's analysis looked at a 100-vehicle fleet of school buses that serves a standard high school. Its commonsense assumptions about charging drew directly from current practices. For example, most school districts fuel and store buses overnight in centralized facilities. The unmanaged scenario assumes the same practice, with drivers parking their buses in the lot upon completion of their routes in the afternoon or early evening. Instead of gassing up the buses, though, operators plug them in before departing for the day. The bus batteries begin refueling immediately, and they continue at a standard flow until they reach full charge.

Itron performed the analysis based on the bus depot being serviced by a large public utility in California. "In terms of impacts on distribution systems, solar panel use and other aspects, our use case is a great proxy, since it signals the direction the entire country is going," says Braby. Analysis of four other representative utilities confirmed the findings.

Unfortunately, typical school bus plug-in time coincides with peak energy demand across American municipalities, when grids strain under pressure and electron flow is at its costliest. Furthermore, this is typically the time that solar generation starts to wane as the sun sets. All plugged in at about the same time, the buses place additional burden on generation, transmission and distribution capabilities. Their batteries' rate of charge is standard, no matter the strain on the grid or the cost of the electricity. Each bus stops charging when it has reached a full charge, typically in the middle of the night, when electricity is cheapest.

In contrast, managed charging automates and optimizes overnight bus charging. Although buses plug in during the grid's peak-demand period, they do not begin drawing electricity then. (In fact, school districts could provide their buses' excess battery-stored electricity during this time as an added benefit to both them and the power company.) Buses wait to charge off-peak, at significantly cheaper rates and less stress on the grid. They fill up slowly and

deliberately, cycling through in a way that places less stress on batteries and district-owned charging equipment. Charging management algorithms ensure that buses have enough charge and are ready for their morning routes.

“We knew that managed charging would make a difference,” Braby says, “but we didn’t know how much of a difference.” By using a smart charging management system, the representative school district could meet its needs with a smaller, less expensive transformer. Installing a 1650 kVA transformer instead of a 5000 kVA transformer gleaned an initial \$162,500 in savings (accounting for hardware and wiring costs, but not costs such as site surveys or grid impact assessments).

The school district saw continuing benefits, too. The smart charging software refueled batteries when electricity was plentiful and inexpensive, saving approximately \$244,000 annually (\$2,440 per vehicle). This represented a 38% benefit in savings versus unmanaged charging, as shown in Figure 2.

This use case, which assumed one EVSE charger per EV bus, provided impressive numbers. Itron modeling showed that plugging multiple buses into the same charger provides further up-front savings.

Itron analysis showed that utilities, too, enjoyed significant cost avoidance. When the school district outfitted its 100-bus depot with a smart charging management system, the utility saved approximately \$60,400 in costs annually or \$604 per charger per year, as Figure 3 shows.

Those savings accrued from reduced distribution infrastructure (\$16,000 per year), reduced cost of distribution maintenance and replacement (\$9,000 per year) and a lower need for electricity (\$198,600 per year). Managed charging can save utilities more than 20% a year through targeted grid infrastructure investments and ongoing management.

These benefits are enhanced when an EV fleet’s charge optimization platform shares data and cooperates with the utility’s grid optimization platform. When that level of system-to-system collaboration occurs, both parties will realize even greater value.

Keeping Them on the Edge of Their Fleet: Conclusion

As EV technology continues its advance in American households, it is breaking into the commercial and rental fleet world. Although some fleet owners may purchase the same EVs as households do, how EV-owning businesses refuel those vehicles involves a decidedly different level of consideration.

Companies considering full-scale EV adoption already know the benefits of EVs themselves, among them lower cost of ownership, environmental benefits and increased social capital. But those companies leave money on the table if they procure the basic vehicles and charging equipment, yet fail to carefully consider the process of charging itself.

The best circumstance is one where fleet-operating companies and utilities start talking well in advance of EV procurement. This scenario allows both to appropriately locate and size infrastructure to provide the charge the companies will need while enhancing grid stability. Stakeholders can agree on charging protocols and ways DERs may contribute to grid capacity during peak demand.

After facilities have been built and EVs have been bought, fleet owners’ and utilities’ optimizing platforms collaborate on a managed charging profile that minimizes battery and equipment degradation, saves maintenance costs and allows EVs to draw electricity when it is most plentiful and least expensive. When that level of cooperation is achieved, we will live not only in a cleaner world, but also a more profitable one.

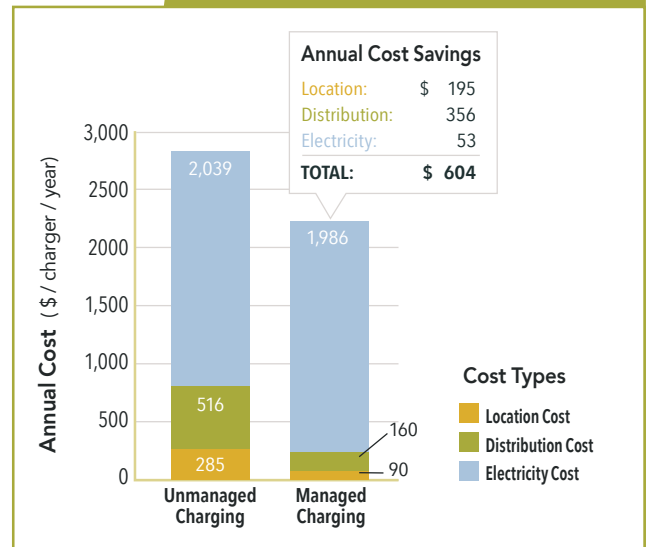


Figure 3: Managed EV charging saves the utility over \$600 per charger per year. Itron’s projection shows that the utility benefits from both decreased operations and maintenance costs and less-expensive grid components.

ComEd Values DER

Utility analyzes how the interconnection of distributed energy resources can provide value to the grid.

AMIN KHODAEI, RALPH MASIELLO, ALEKSI PAASO, SHAY BAHRAMIRAD
ORIGINALLY PUBLISHED SEPTEMBER 5, 2019



Distributed energy resources like solar photovoltaics and energy storage offer terrific opportunities to mitigate the effects of climate change and invigorate the economy. To realize this potential, electric utilities must be able to calculate the value of distributed energy resources (DER) fairly and accurately. As these resources are interconnected to the grid, they can pose challenges, including an increased need for utilities to be able to observe and control the more distributed grid.

With challenges also come benefits. By interconnecting to the grid, the resources not only potentially promote sustainability and support efforts to enhance societal resilience, but they also can make the grid

more economical. This requires a rigorous analysis of how the interconnection of DER can provide value to the grid. Commonwealth Edison Co. (ComEd) has developed a methodology to do just that.

HOW DER PROVIDES VALUE

The primary way DER provides value to the grid is by deferring traditional grid investments. DER can leverage potentially one or more of three types of resources: real power, reactive power, and reserves. As the distribution grid is designed currently, wired grid investments such as transformer upgrades or the installation of capacitor banks often are done to increase the availability of real or reactive power,

respectively, in an area of the grid. Should DER be able to provide that same resource, it could defer the need for upgrades and potentially reduce the cost of planning the system.

The challenge is that the real or reactive power would have to be injected into the grid at both a particular place and time. Unlike the transmission grid, most distribution grids are radial, meaning each feeder inter-connects with only a single sub-station. Therefore, capacity upgrades typically are installed to mitigate constraints that occur on a feeder between the substation and certain loads or within the substation itself. Thus, a DER interconnected to an adjacent feeder does not defer projects on the feeder with constraints. Even if a DER were interconnected on the relevant feeder but upstream of the constraint, it may not be able to provide value to the planning of the grid.

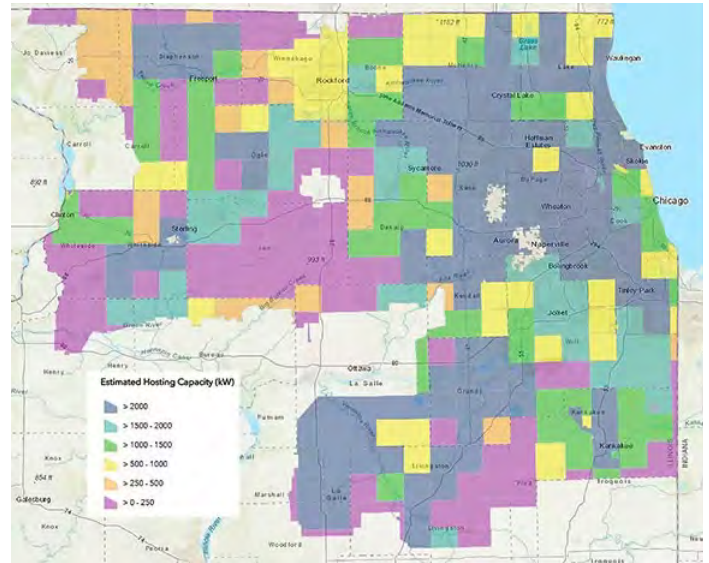
DER not only needs to be interconnected at specific locations to provide value from a grid-planning perspective, they also must provide the relevant resource at the appropriate time. Because load varies over time, a constraint might only appear for a given set of hours on a given number of days. DER would need to provide sufficient real and reactive power to mitigate the constraint when it occurs. This could provide benefits to customers, measured potentially in terms of dollars and cents.

EXISTING APPROACHES

ComEd began evaluating existing methodologies to recognize the value of DER. Many of these approaches faced common problems. One approach was to use average values to determine contributions to the grid, which would reduce significantly the computational burden of implementing value-of-DER methodology.

Because a utility's distribution system basically comprises thousands of discrete feeders interconnected only at substations, estimating an average value could lead to significantly overcompensating some DER while undercompensating others. The effect would likely increase the cost of planning the grid, because owners would be under-incentivized to interconnect DER where it is needed most. It also could lead to requiring costly traditional wired solutions and over-incentivizing DER owners to interconnect where the value may be less for the system.

Across the U.S., utilities have looked at different approaches and considered factors other than impact on the grid. A significant benefit of DER — acknowledged in other industry efforts — is reducing carbon emissions, which can be valued monetarily through estimates of the cost of carbon. ComEd recognized combining this factor with grid concerns could lead to the task of planning and operating the grid in an overly expensive way, because the utility would be required to offer incremental services.



Only by developing an approach that focuses strictly on the services DER can provide to the grid would it be possible for stakeholders to make informed decisions about it, without affecting the operation of the grid. This would make it possible to integrate high levels of renewable generation.

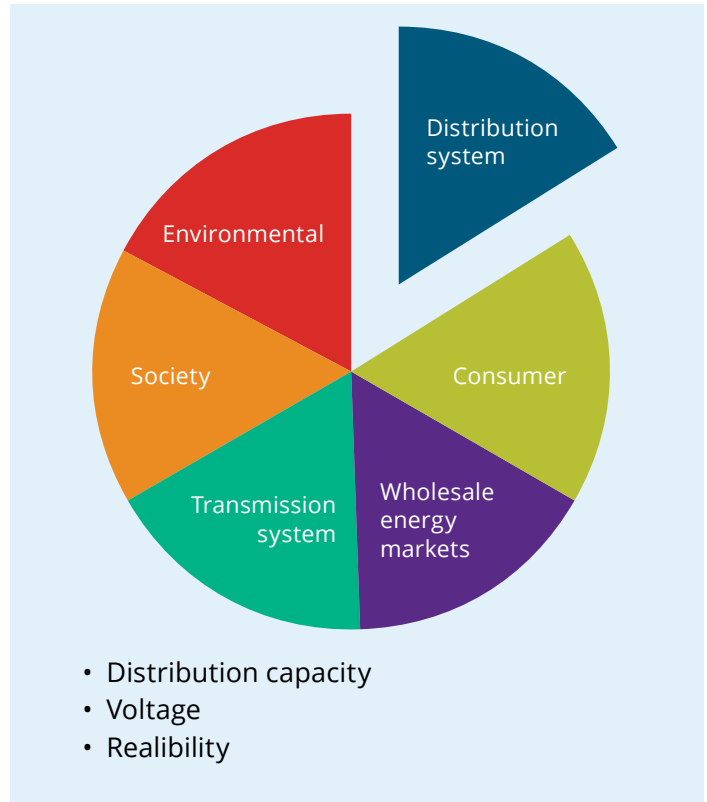
COMED'S APPROACH

In developing this approach, ComEd was confident the primary ways DER provides value to the grid is by deferring investments to increase capacity, mitigate voltage issues and enhance reliability. The only problem was no methodology existed to make such an assessment, much less demonstrate it on a utility grid. ComEd also benchmarked with those working on the locational net benefit analysis (LNBA) in California, U.S., which similarly aimed to produce a geographically and temporally granular basis focusing strictly on the value to the grid. None of these approaches produced sufficiently granular results or considered the effects of reactive power.

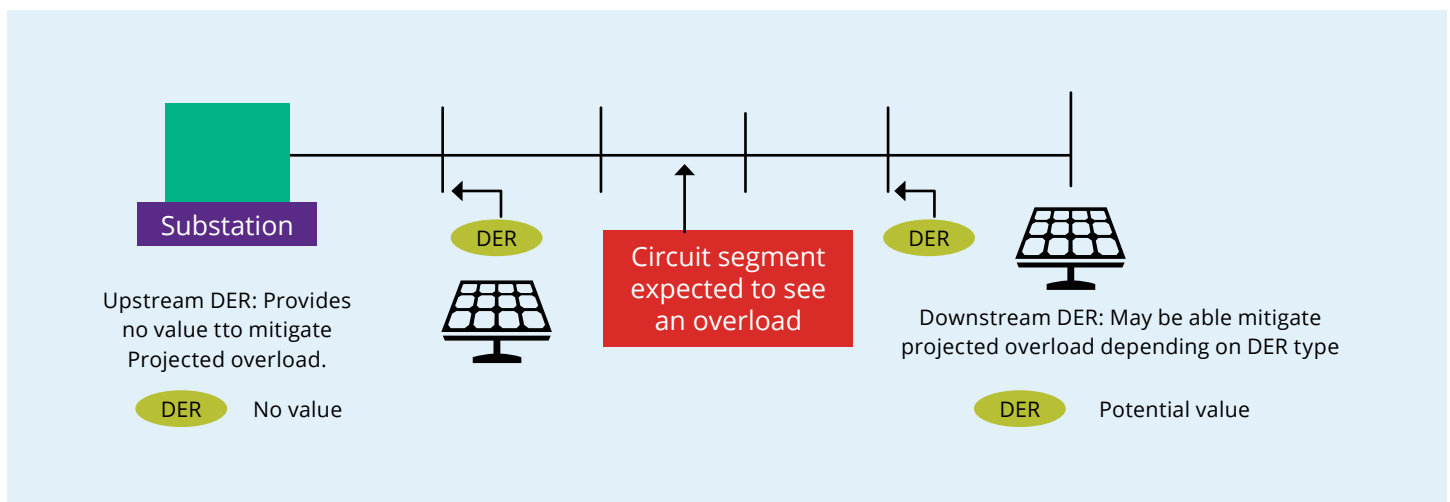
To develop its methodology, ComEd formed a team with diverse talents. Members ranged from academics as well as technical and economist thought leaders in industry—who had extensive theoretical expertise in energy markets—to smart grid engineers and capacity planners—who had deep experience with the grid. Partnerships with PLUG LLC, Quanta Technology LLC and Tabors Caramanis Rudkevich helped to ensure there was the right expertise and experience to answer questions in a rigorous manner.

External experts helped to develop the mathematical theories and tools to demonstrate them in the real world. ComEd’s engineers helped to prioritize the value DER provides for capacity upgrades, because of the higher cost of deferring them, and deemphasize the importance of reduced losses along a feeder by noting such impact is largely nominal. Additionally, the utility engineers helped to explain how academic theories had to be fine-tuned to respond to the physical realities of the grid. The collaboration of these experts with varied types of skills demonstrated how a team can be more than the sum of its parts.

Broadly speaking, what emerged from this work was an innovative approach to analyzing the grid, to determine exactly what additional capabilities would be needed to mitigate emerging issues. Engineers considered potential approaches using traditional wired solutions to determine what would be the most cost-effective method to solve a problem. Once this was identified, a mathematical methodology was developed to allocate a value to any DER that might be interconnected in place of the traditional wired solution.



By emphasizing the grid contribution of DER, ComEd’s approach is technology agnostic. In other words, DER is compensated equally—regardless of whether it is photovoltaics (PV), a fly-wheel battery or demand response—if it provides the necessary energy resource at the appropriate time in the relevant location. This approach encourages stakeholders to pursue innovative approaches to integrating more advanced technologies into the grid and monetizing them from a range of value streams, including the value of DER.





Location Awareness

Distributed Intelligence

Effectively using your smart meters to support monitoring and control of your secondary distribution requires knowing exactly where they are in your distribution network.

One of the greatest obstacles to the evolution of the electric distribution grid is the inability of smart meters and other equipment to know precisely how they are connected to the distribution grid. This lack of operational information impacts all aspects of grid operations from load control of distributed energy resources and intelligent switching to phase balancing and system reliability.

Now, for the first time, smart meters using Itron distributed intelligence can be continuously aware of their electrical connectivity in relation to other grid assets. This awareness does not require a GIS component nor is it dependent on the topology of the communications network. Rather it's enabled by continuous monitoring and analysis of electrical characteristics relative to other devices on the network.

This capability, called Location Awareness, is a fundamental breakthrough in the Itron network and distributed intelligence platforms, which enable an entirely new frontier of smart grid use cases and applications not achievable without timely and reliable connectivity data.

The Value of Location Awareness

- » Sub-second data resolution provides higher accuracy than previously possible
- » Requires significantly less back office infrastructure and data science expertise
- » Device self-awareness of electrical location greatly improves many outcomes such as outage and theft detection, and network connectivity
- » PLC connectivity delivers accurate and rapid phase detection and transformer connectivity
- » Typically, can realize more than \$2M per year in added business case value for utilities with >1 million customers



Based on Itron research with utility customers, the accuracy of connectivity data can vary greatly, with many lacking accurate and updated connectivity data for 10, 20 or even 50 percent of their delivery points. Many rely solely on outdated, as-built engineering drawings from decades ago or imprecise GIS data to make educated guesses on connectivity.

Itron's patented Location Awareness analysis, available with the Itron network and distributed intelligence solution, identifies the electrical connectivity of each meter on the distribution network. The algorithms determine the connected transformer, circuit phase and feeder of each service point and continually update operators with a highly accurate connectivity model.

This unprecedented visibility into connectivity enables Itron to unlock tremendous new value in distribution operations. This information greatly increases the effectiveness of existing processes such as outage and theft detection, transformer load management and demand response, while also enabling entirely new applications like the detection of potentially unsafe grid conditions such as high-impedance connections (HIC) and downed conductors. Location Awareness enables operators to execute localized grid operation use cases with much more confidence and precision than ever before possible.

BUSINESS VALUE

A highly accurate connectivity model delivers precision and accuracy when executing operations anywhere on the distribution grid. Phase balancing, transformer load management, demand response, outage detection and energy diversion detection are just some of the use cases that take on a whole new level of precision and effectiveness when devices know their location in the context of the distribution network.

For transformer load management or demand response, specific loads and distributed generation assets can be controlled to flatten peak loads and manage the grid in a targeted and coordinated manner. The accuracy and timeliness of outage and high impedance detection is greatly increased.

Location Awareness is a fundamental capability of the Itron network and distributed intelligence platforms where intelligent devices continuously analyze data at the edge, communicate and collaborate with each other, and ultimately make decisions in near real-time. When meters and other edge devices are aware of their exact location on the grid, and other devices they are connected to, grid operators are able to solve problems, manage rapidly changing conditions and create new opportunities never before possible.



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Grid Operations



RISING TO THE CHALLENGE

Market forces and new technologies are driving you to transform your operations and business capabilities. An increasingly interactive grid, rising public expectations and accountability, government mandates and faster outage restoration are just some of these factors. Addressing distributed generation, electric vehicles, consumer engagement, extreme weather, microgrids and local markets requires optimization of the low voltage grid and enhanced information fed into various systems.

Itron's Grid Operations outcomes support data intelligence to enable you to develop proactive asset management strategies and optimize your grid. Through a combination of software and services, you are given the tools to gain valuable insight into your operations, maximize asset life, enhance efficiency and improve customer satisfaction.

Transformer Load Monitoring

Changing weather patterns, aging infrastructure and increased adoption of electric vehicles and other technologies are creating new challenges to effectively manage your distribution assets. Transformer Load Monitoring utilizes smart meter data from AMI meters along with weather information to calculate distribution transformer loading and its effect on asset longevity at a scale and accuracy never before possible. Loss-of-life calculations assist your planners in effectively allocating capital for proactive transformer replacement where necessary.

- » Receive alerts to newly overloaded transformers so you can take action before damage occurs or customers are impacted
- » Identify over-utilized, under-utilized and at-risk transformers
- » Assess unanticipated load increases that may result in asset failure
- » Evaluate transformer sizing for new loads using measured load history during peak seasonal loads

Grid Connectivity

Grid Connectivity uses machine learning and AMI meter voltage data to determine meter-to-transformer connections and phase identification. Accurate and up-to-date connectivity data is essential for efficient outage management, system planning, load flow calculations, phase balancing and many other critical grid management operations.

This analysis runs seamlessly in the back office to continually detect when new customers come online, crews perform maintenance and proactive activities like phase balancing and feeder reconfigurations occur. Results are compared to a utility's systems of record so inaccuracies are identified and can be corrected.

- » Improve your load forecasting capabilities with accurate connectivity models
- » Optimize asset utilization and extend asset life
- » Improve outage response and restoration time – improve SAIDI/SAIFI/CAIFI
- » Improve many outcomes, such as outage and theft detection
- » Reduce technical loss by phase balancing

Electric Vehicle (EV) Detection

EV Detection identifies the presence of electric vehicle charging equipment at the customer premise. EV charging can add considerable strain on a utility's delivery network, especially when customers are charging at the same time in the same vicinity.

Awareness and understanding of EV loading enables utilities to measure the impact of these new loads, identify overloaded assets and develop targeted solutions. Knowledge of EV adoption and load is valuable for a variety of other system planning and operations tasks, and for customer marketing programs aimed at providing the best possible experience for electric vehicle owners.

- » Target EV owner awareness of rate programs and incentives
- » Recognize high EV adoption areas to monitor grid impact
- » Correlate overloaded assets with presence of EVs

Solar Detection

Solar Detection identifies the presence of solar generation behind the customer's revenue meter at the premise. This information can be used for system planning, customer marketing programs associated with distributed generation and a variety of other customer-focused use cases.

- » Ensure customers are on the right rate program
- » Enhance safety through awareness of back-feed potential
- » Inform customers if solar generation is offline
- » Associate over-voltage areas with high solar adoption



FAST DEPLOYMENT AND TIME TO VALUE

Grid Operations applications are offered as Software as a Service (SaaS) utilizing the Microsoft Azure cloud platform. Itron's SaaS-based approach helps you realize value quickly and, at the same time, supports scaling deployments at a pace that is comfortable.

END-TO-END ACTIVE GRID SOLUTION

Grid Operations applications are pre-integrated with Itron's market-leading smart grid solutions to reduce risk, lower implementation costs and provide faster time to value. With this integration, Itron provides you with a complete smart grid solution including meters, sensors, networking, data collection, data management and consulting services—to ultimately solve your business challenges and deliver value-based outcomes.

Grid Operations applications also include data integration adapters which integrate to third-party systems such as GIS, workforce management, CIS systems and third-party AMI and MDM systems.

FOCUS ON CONTINUING INNOVATION

We strongly believe that analytics is a key component to extending the value of smart metering and smart grids. Itron is making significant investments in research and development to discover and productize new analytics use cases and algorithms. By leveraging our Grid Operations applications, you will benefit from this continuous investment in innovation.

ENSURE GRID RELIABILITY & RESILIENCY

You are now faced with more rapid change and increased expectations than before. The grid is more participatory (two-way), there are ongoing increases in the reliability, service and engagement level that customers expect, and regulators have high expectations that utilities will meet those mandates.

Itron's years of industry insight and experience, combined with our Grid Operations applications, will provide you with the cutting-edge analytic capabilities of today and prepare you for the emerging priorities of tomorrow. We enable you to realize the full value of your smart grid.



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To learn more visit **itron.com**

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Distributed Intelligence: Creating the Future for Utilities

Gary Kessler
Senior Product Manager, Itron



New challenges for the utility industry are presented every day. Continued innovation has created a plethora of new and exciting opportunities for the utility industry in every commodity. For electricity, multi-directional power flows in the LV network, created by photovoltaics, electric vehicles, storage penetration and consumer service expectations—driven by digital economy revolution and players like Google, Amazon and Apple—have driven many changes in to utility market.

These opportunities are a catalyst for new business models based on energy balancing, reactivity and customer focus. As a result, utilities need new tools to retain a position as a provider and enabler for energy consumers.

UTILITIES AND COMMUNITIES IN TRANSITION

Over the past several years, powerful trends have emerged that are affecting infrastructure investments and decision making by utilities and communities. More than just grid modernization, there are critical events that affect core utility infrastructure. Aging capital assets such as transmission lines, transformers, distribution assets and grid security are affecting utilities capital decisions. Include the impact of environmental issues such as severe weather, resource sustainability and wildfire management, and this creates large unplanned impacts on core utility infrastructure. Include pandemics, which have a huge impact on utility workforce, and modern utilities have a difficult set of issues facing them.

All these observations and changing customer expectations have created an environment where utilities must evolve, change and upgrade infrastructure, business models and operational strategies to survive. These conditions are driving grid modernization and new use cases. The result of ignoring these indicators is bankruptcy and reorganization of the utility.

Some factors that are currently affecting how utilities operate now, and in the future, include:

- » The rise of renewable distributed generation (and utility use of renewables) to create a more dynamic and non-dispatchable source of energy
- » An increase in the number of prosumers and rates that create multi-directional low voltage networks, including programs such as solar buyback and using EV batteries for peak flattening
- » Rapid urbanization with increased population density is driving the need for more apartments and less single-family home ownership. There is also an emphasis on sustainability and low-impact living.
- » Consumers demanding choice in their electric providers, renewable energy and pricing plans, etc.

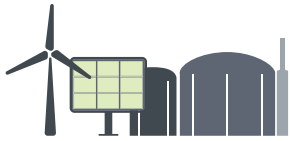
In addition, the evolving digital economy is creating consumer expectations of immediacy such as:

- » Same-day delivery
- » “Digital assistants” that provide instant information based on searching the internet
- » Instant access to anybody who has a cell phone as well as SMS where text exchanges happen instantly

The examples above are part of building instant gratification expectations and the expectation of “right here, right now”. Our world is becoming the “instant” society where waiting is not tolerated—and is an inconvenience.

These events are building a new community model that drives customer’s expectations, and the utilities that support them, into new business areas, rate models and use cases.

With access to every consumer in its territory, how can utilities play a central role in this evolving model? Today, the utility serves their base load and peak loads using traditional, centralized generation capabilities and supplementing with power purchases from the wholesale market. Incorporating decentralized generation from prosumers is just beginning to evolve in the utility operational model.



DECARBONIZATION & RENEWABLE GENERATION

More dynamic, less predictable generation fleets. Cleaner gas mixes and increased focus on safety.



ACCELERATION OF PROSUMER MODELS

A fluid, multi-directional low voltage network.



RAPID URBANIZATION & DEVELOPMENT

Increasing population density. Emphasis on sustainability and resiliency.



DIGITAL ECONOMY-DRIVEN CONSUMER EXPECTATIONS

“Right here, right now.”

Factors Affecting Utility Infrastructure & Vision

THE CHANGING GRID

As the prosumer evolves, and decentralized generation becomes more prevalent, the rise of microgrids becomes more prevalent. Microgrids are those islands of generation servicing a small, connected group of consumers. Microgrids add a level of resiliency to the grid by continuing to operate during a main grid outage. The utility will need to define the requirements for microgrid connectivity and re-connectivity to the main power grid. This creates the opportunity for a value-added rate/tariff of how the utility serves the microgrid and its connectivity to the utility grid.

Utilities and communities can work together through public-private partnerships and other means to provide advanced services and revenue streams to each other and to citizens. Services such as EV charging, water data collection and billing, water conservation and streetlight controls are examples of these advanced services.

A report by the Rocky Mountain Institute on “Navigating Utility Business Model Reform”¹ discusses many of the issues facing utilities as new regulatory policies begin to roll out across the country. The report outlines four areas that are driving change:

1. Adjustments to the Cost-of-Service Model
2. Leveling the Playing Field
3. Retirement of Uneconomic Assets
4. Reimagined Utility Business

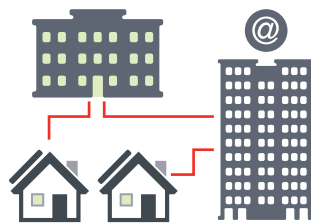
Each of these four areas of reform, and the use cases associated with them, creates a significant change for how utilities need to think about future planning. Adjustments to the Cost-of-Service model encompasses major changes to how utilities interact with their customers. Revenue decoupling, multi-year rate plans and performance-based incentives are all examples of regulatory changes that drive a major shift in utility business models and consumer expectations.

As these changes become part of the utility business model, consumer energy services (value-added services that the utility provides for the consumer) become part of the consumer’s menu of choices. These services may include leasing solar to the consumer or providing an energy arbitrage for those deregulated markets. Today, these services are being created by independent, non-utility companies that are filling in the consumer energy services space. Examples include solar plant providers that install solar panels on consumers’ homes in return for tax credits or EV charging companies that provide public EV charging stations. All are opportunities for the utility, when enabled by regulatory bodies.

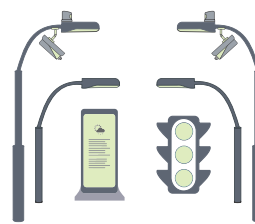
These opportunities are driving change to occur in this space, and it is just the beginning. IoT technology has created an enabler to help us move from the old energy model to a new energy model. With proper planning and execution, IoT tech enables utilities to stay relevant and provide real value to their stakeholders. But, it is the vertically integrated platform, outcomes and solutions that



BASE AND PEAK LOAD SERVICES



CONNECTING GRID ISLANDS



CONNECTED COMMUNITIES



CONSUMER ENERGY SERVICES

New Utility Community Models

¹Cross-Call, Goldenberg, Guccione, Gold & O’Boyle. *Navigating Utility Business Model Reform*. November 2018. <https://rmi.org/insight/navigating-utility-business-model-reform>

support that platform, not the technology itself, that makes this possible. Some of the key opportunities where utilities can use IoT to create valuable outcomes are:

- » **Improving safety for consumers and field crews:** the utility's core mission has been to provide safe, reliable and resilient power. This remains true for both consumers and the field crews that keep the lights on. Smart sensors can proactively identify safety concerns.
- » **Opening new business models:** In the old model, utilities made significant investment in capital equipment and then earned a return on it by providing energy to their customers. Now, their customers are generating and storing their own energy, and are focused on using less of it. That traditional model is slowly going away, creating new opportunities for utilities to become an energy management services provider: support distributed generation, but provide grid services as needed/desired. This opens the opportunity for Distributed Energy Management to enhance grid sustainability and reliability.
- » **Enabling transactive services:** Utilities and cities alike are becoming platform providers that enable third parties and end consumers to connect to a common, integrated platform. Utilities, for example, can enable consumers to be buyers and sellers of electricity, depending on the system's needs, customer needs and capabilities, and price factors that can incent the customer to be an energy taker or provider, including inter-customer transaction (this requires new thinking and regulation change).
- » **Engaging and equipping prosumers:** Consumers can control their loads in response to prices and/or signals from a grid operator, as well as owning their own generation or storage. And they can choose to use those products or offer them to the grid. This is a new relationship for utilities and their customers.

For smart communities, this means providing an application enablement platform that utilizes the same network and back-office application platform. Communities worldwide are increasingly adopting open data models that enable them to share data with third-party providers. Third-party providers likewise need an easy way to access this data so it can be incorporated into their applications.
- » **Enhancing resilience and reliability:** The increasing frequency of severe weather events, coupled with greater consumer expectation for "always-on" services, makes reliability a top priority.
- » **Delivering a 3D ROI:** Utilities and cities are investing in critical communication infrastructure that can be used to enable new services for connected communities. As utilities and communities evaluate new services, they are embracing value beyond traditional economic ROI, including environmental and social benefits of solutions.

Instead of a traditional generation/transmission/distribution

model, distributed energy resources (DER) such as solar and wind, are driving significant investment in grid modernization to provide greater awareness, control and flexibility of these new distributed, decentralized energy systems. In a decentralized power system, utilities must account for bi-directional power, transaction management and storage.

THE TECHNOLOGY INVASION

As the use of microprocessors in smart phones and IoT devices drives down cost of advanced microprocessors, it becomes more cost effective to integrate these devices into meters. This is a direct outcome of Moore's law² and its intersection with the Rodgers Adoption Curve³. The use of powerful microprocessors in meters creates the capability for high-frequency sampling and additional processing power to run local analytics. The evolution of the meter from a single-focus device that only collects consumption data, to a device with an embedded operating system, has created a powerful endpoint. This combination enables the meter to function as a real-time network monitoring and control device, a powerful and flexible engine for user engagement and development of efficient operational processes.

The utility has the key advantage of having prime real estate on the side of every customer's home. With an advanced meter on every home premise, capable of high-frequency data capture and on-site analysis, the utility has the ability to provide its customers with significant insights, information and actions that decrease the consumers' costs and increase the utility's efficiency and metrics. Examples of this include high impedance detection and load disaggregation to more advanced capabilities such as location awareness and active demand response. New market opportunities could open neighborhood energy markets and power trading within microgrids. The value that can be unlocked using distributed intelligence capabilities will be enabled by the coming regulatory changes above and the utility's vision of the future.

Meeting the challenge of servicing these new markets requires a broad and comprehensive vision that provides choice to the consumer and utility. An open architecture that supports a vibrant ecosystem of solution providers will be key in the success of this vision. Enablement of a partner ecosystem is critical to ensure reactivity, continuous innovation and the opportunity to support a business and operations model that encourages innovation.

EMPOWERING BUSINESS TRANSFORMATION

The changing market is creating a difficult trend for utilities to navigate. There is the trend for residential and small commercial customers to demand greater value and a more personalized experience from their energy provider, creating higher regulatory hurdles for utility rate cases. Large commercial customers are demanding more ability to control their own consumption and spend on energy, pushing a more decentralized grid to support emerging microgrids where commercial (and some prosumers) distributed energy resources combine to create localized energy networks that can disconnect from the grid and operate autonomously.

²Technology Adoption Lifecycle, https://en.wikipedia.org/wiki/Technology_adoption_life_cycle

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As the new regulatory model becomes more prevalent, consumers—both large and small—are no longer bill payers, they are stakeholders. Their activities are driving the utilities' direction. Residential consumers are buying more electric cars and by 2040, it is estimated that 50% of new cars will be electric vehicles. This requires the right infrastructure to charge, manage and maintain these cars and the load they create on the electricity grid. Large commercial customers are asking for higher power quality at lower prices. They are becoming transmission customers, and building their own substations, power generation and power control systems, where they can design grids to meet their specific needs. These changes have large implications on how utilities manage capacity and account for energy transactions. These are a broad, complex set of challenges that requires a long-range vision and extensible capabilities that will enable management of distributed assets and new technologies across multiple domains and geographies.

INTELLIGENCE THAT EMPOWERS

Our strategy is to deliver the right information in the right place at the right time so our utility customers can meet the demands of their evolving markets and new regulatory business models. By enabling smart meter technology that exists at the edge of the network, using intelligent connectivity and smart devices, an active grid with intelligent connectivity is created to support this new market paradigm.

Our Distributed Intelligence (DI) vision goes beyond the meter and extends to a broad ecosystem of devices that can be connected to create a vibrant, active grid enabled by intelligent connectivity that creates capability at the edge of the grid. Capability that applies analysis, decision making and action where it is best utilized for the most valuable outcome. We are enabling DI for the broad collective of use cases in smart communities.

Distributed Intelligence-enabled Use Cases

While this complex challenge has many opportunities, we are focusing on three areas:

- » **Gas safety and water conservation:** autonomous action taken at the smart IoT device—methane, pressure and temperature sensing—allows gas valves to close without human interaction
- » **Grid management and smart cities:** enables intelligence in aftermarket devices by retrofitting them with a comms module and utilizing an Itron IoT Edge Router to act at the router level
- » **Utility grid optimization and consumer services enablement:** creates more efficiencies in the delivery of energy to prosumers, enabling grid resiliency and redundancy by incorporating DERMS and extending infrastructure life

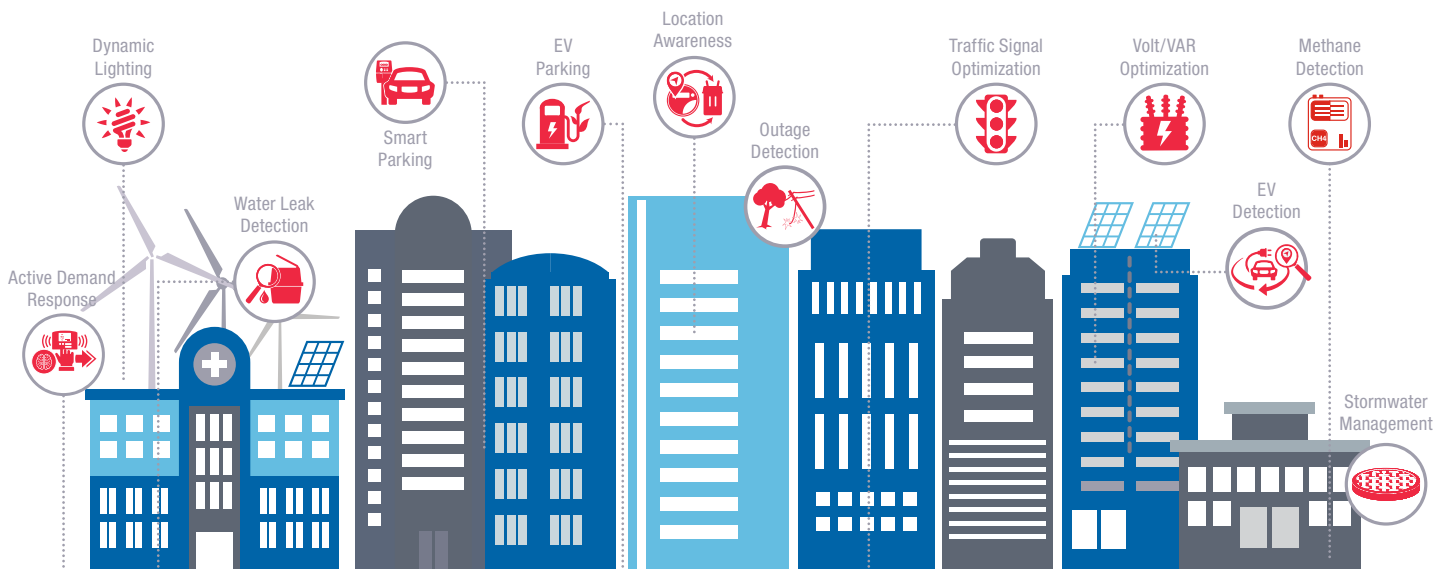
Can this vision realistically be implemented into a viable solution that scales to meet the demands of the new market requirements? Yes.

BUILDING BLOCKS FOR THE FUTURE

A key pillar to building a broad solution, our Distributed Intelligence platform applies analysis, decision making and action where it is best utilized for the most valuable outcome.

The first step is the ability to create, access, control, analyze and deliver power while monitoring and reacting to local events. Power delivered or created locally must be stable, reliable and dispatchable. Distributed Intelligence creates the platform that is required to enable Active Demand Response, Outage, Volt/Var Optimization and a myriad of other key use cases. Our DI platform enables these concepts to become reality.

Meters have gone from measuring only consumption to becoming an embedded computer in every device. Now there is a computer on the side of most homes and business (where regulators have the foresight to allow AMI and advanced technology projects) available in the form of a meter.



Evolving Smart Communities

With this shift in technology, utilities have access to high-resolution data at the endpoint or meter. That enables the capability to look at waveform data for electric, interval usage for water and gas, and potentially load disaggregation for gas and water.

Adding peer-to-peer communications between meters and devices creates the ability for devices to compare information and status. By enabling peer-to-peer capabilities, devices can use “bee-hive”-like communications, where one device can tell another device that an event is occurring, and the other device can validate or invalidate the event as it applies to them and pass that information to other devices. That information is aggregated into an event or non-event depending on the collective outcome.

With the complexity of the information provided, and the broad nature of the solution, having an open and vibrant ecosystem of partners and solution providers creates more opportunity for the consumer to capture the value of this technology shift. An example might be power brokering between neighbors in a microgrid or retail power market. Another example is providing real-time communications that give utilities the ability to provide more grid reliability such as management of distributed energy resources during a critical peak event.

Having this capability at the edge of the utility network, especially the electric network, creates an opportunity to develop advanced solutions that meet the needs of smart cities, prosumers and future regulatory requirements.

After evaluating these markets and our customers’ requests, we have created distributed intelligence applications and begun distribution of these apps to key electric customers. We have created apps that enhance our customers’ ability to serve their customers.

Each of these apps address some of the common use cases that electric utilities manage every day. These apps provide enhanced value to the utilities and the customers they serve. The apps listed below are the building blocks for a utility’s evolution to meet the new market challenges.

» **High Impedance Detection:** The High Impedance Detection DI app provides detection of high-impedance connections (poor electrical connections) in the low voltage (LV) secondary distribution. High-impedance connections cause customer voltage flicker, interruptions and potential fire risk. Early detection allows maintenance work to be scheduled rather than corrected through one-off trouble calls and for the condition often to be resolved before impacting customers.

» **Theft Detection:** The Theft Detection DI app provides detection of bypass tampering at the electricity revenue meter where jumpers are placed around the meter to steal electricity.

» **Residential Neutral Fault Detection:** The Residential Neutral Fault Detection DI app provides detection of loss of neutral connectivity at a standard residential three-wire, form two, meter service. A broken neutral condition can cause consumer equipment damage and unsafe conditions.

» **Outage Detection:** The Outage Detection DI app provides more rapid and accurate identification and location of major outages by optimizing the use of the communication network for outage messages during storm conditions. Communication network statistics and Location Awareness are used on each meter to select optimal bellwether meters for outage notification and detection. During storm mode, only bellwether meters will report outages, maximizing the likelihood that highest priority outage messages will be received.

» **Location Awareness:** The Location Awareness DI app provides the electrical location of every meter on the distribution grid, including transformer, phase and feeder. This information is used by multiple DI apps and is also delivered to the back office for update and validation of GIS connectivity, improved outage response, feeder phase balancing and multiple other grid applications.

» **Load Disaggregation:** The Load Disaggregation DI app provides disaggregation of the whole premise electric load into the individual electric appliances and loads within the premise, in the form of time series load profiles for the individual loads. This information can be used for numerous customer and utility operations applications and programs.

Distributed intelligence empowers forward-looking utilities to evolve new business models using these key applications and build their own applications. Distributed intelligence, delivered in conjunction with intelligent connectivity—on an industry-leading IoT-based network and rich ecosystem of multi-service use cases—allows this evolution to occur. This facilitates future planning to align with their customer’s needs and the changing market driving their business model. Delivering key information to the right place and at the right time will improve grid efficiency, reliability and safety, transform customer service and decrease operational costs. Insight, innovation, enablement and trust will be the pillars for utilities to succeed in navigating the new business models. Itron distributed intelligence empowers the business transformation necessary for utilities to succeed and be in the **know** about their customers and their grid.



Join us in creating a more **resourceful world**.
To learn more visit **itron.com**

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What if we could stop fires before they start?

With the right network, real-time monitoring and our in-meter edge intelligence app, hot spots are easier to detect.

This allows you to quickly identify and respond to electrical connections that result in poor service and potentially dangerous conditions.

Protecting property, saving lives—and preventing disasters before they happen.

More intelligence. More possibilities.

Itron

itron.com/DI





RESOURCES

- » **BLOG: Beyond Run to Fail: Redefining Low-voltage Grid Management**
 - Learn about our targeted portfolio to address low-voltage grid challenges.
- » **BLOG: Where Am I? — Are Your Assets Self-Aware of Their Location on the Grid?**
 - Understand where—and how—your assets are electrically connected on the grid.
- » **BROCHURE: Distributed Intelligence**
 - Learn how distributed intelligence can help optimize the grid, manage assets, integrate DERs and enhance customer engagement.
- » **BROCHURE: High Impedance Detection**
 - Identify low-voltage distribution hot spots early and in real-time to save time, money and keep customers safe.
- » **BROCHURE: Location Awareness**
 - Improve safety, operational efficiencies, restoration efforts and resiliency.
- » **BROCHURE: Residential Neutral Fault Detection**
 - Improve safety and customer service, avoid customer equipment damage, reduce resolution time and lower costs.
- » **BROCHURE: Meter Bypass Detection**
 - Recover revenue by detecting meter tampering and complex diversion schemes.
- » **USE CASE: High Impedance Detection**
 - Unlock new value and increase visibility through advanced sensing and data processing to spot high-impedance faults and related grid safety issues.
- » **VIDEO: Distributed Intelligence Applications**
 - Collaborate intelligently in real time with edge intelligence to solve problems and manage rapidly changing conditions.
- » **VIDEO: Distributed Intelligence Drivers & Considerations**
 - Learn more about both the drivers behind distributed intelligence and what utilities should take into consideration when assessing the opportunity to move toward a more active grid.
- » **VIDEO: Next-generation AMI: Expand and Gain Maximum Value from Your Investments**
 - Capitalize on innovation, such as smart energy networks, to realize an immediate ROI and gain maximum value with more sophisticated and targeted use cases.
- » **WEBPAGE: Distributed Intelligence**
 - Learn about distributed intelligence and its value, applications, successes and partner ecosystem.

ABOUT ITRON

Itron enables utilities and cities to safely, securely and reliably deliver critical infrastructure solutions to communities in more than 100 countries. Our portfolio of smart networks, software, services, meters and sensors helps our customers better manage electricity, gas and water resources for the people they serve. By working with our customers to ensure their success, we help improve the quality of life, ensure the safety and promote the well-being of millions of people around the globe. Itron is dedicated to creating a more resourceful world. Join us: www.itron.com.

CONTACT US

Begin your journey to deliver intelligence that empowers.

We are here to help.

